

Solar mass:
 $1.98 \times 10^{33} \text{ gm}$

Solar radius:
 $6.96 \times 10^{10} \text{ cm}$

Mean Solar density:
 1.410 gm cm^{-3}

Visual magnitude
of the Sun: -26.73

Absolute visual
magnitude of the
Sun: +4.84

Quiescent Solar
surface
temperature:
5800 K

Solar polar rotation
period: 31.52 days
(sunspot method)

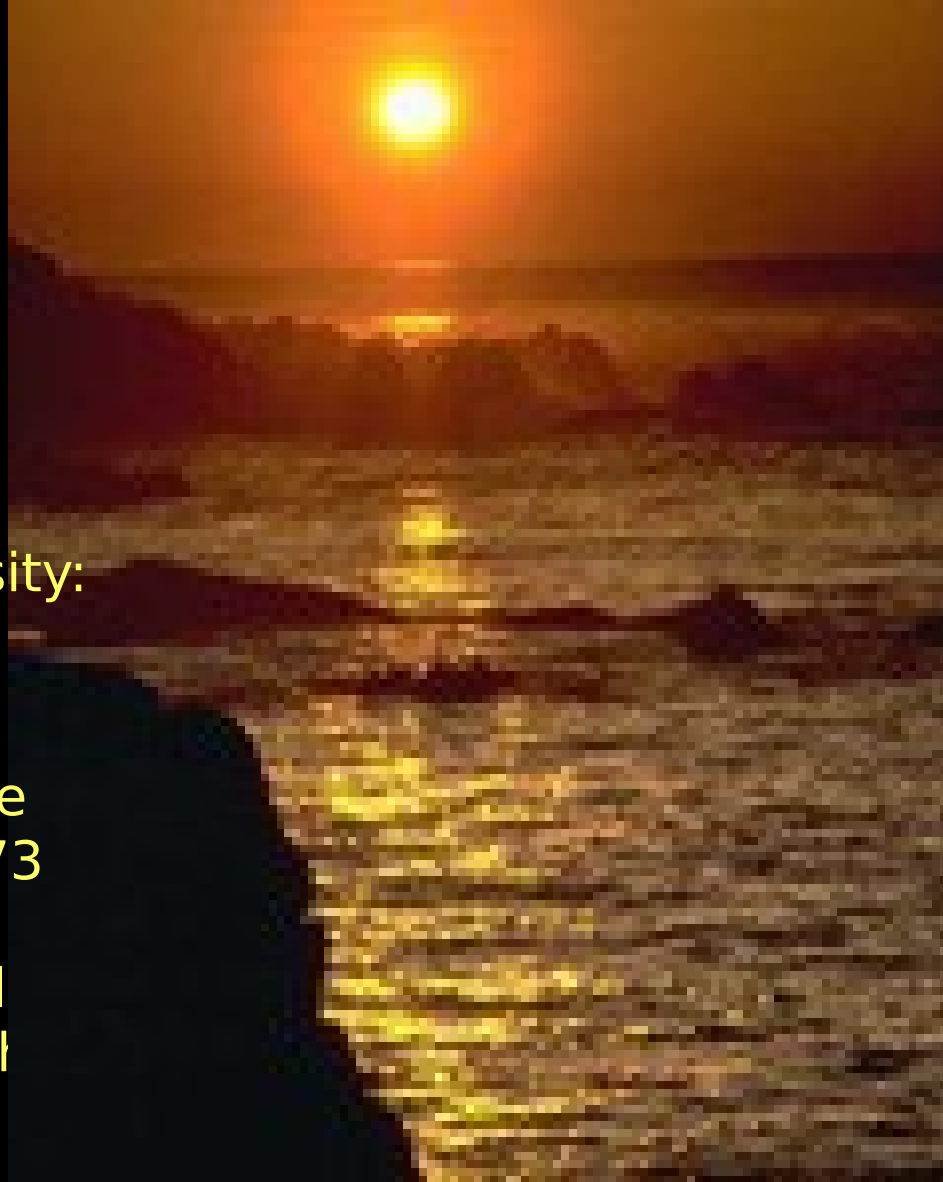
Solar equatorial rotation
period: 25.0 days (using
sunspots)

SUN

Quiescent Solar
luminosity:
 $3.83 \times 10^{33} \text{ ergs/s}$

Earth-Sun
distance:
(1 AU): $1.5 \times 10^{13} \text{ cm}$
Solar constant:
 $0.1353 \text{ Watts cm}^{-2}$

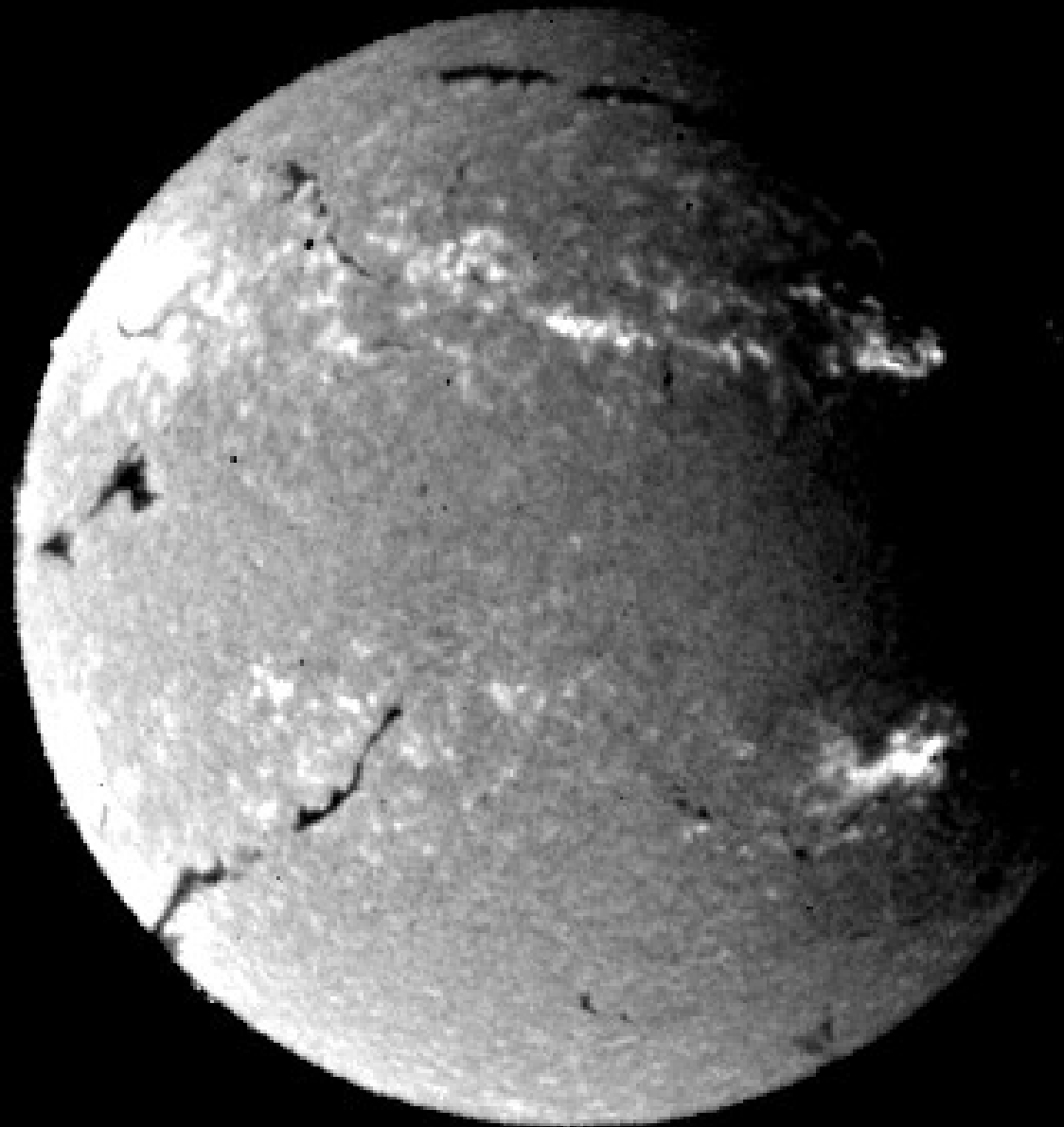
Solar surface gravity:
 $2.74 \times 10^4 \text{ cm/sec}^2$



Sun, MLSO, $H\alpha$

$H\alpha$ (6562.8 nm)
images from
the High
Altitude
Mauna Loa Sol
ar Observator
y
(012199)

$H\alpha$ emission is recombination radiation from hot gas in the photosphere. In the chromosphere, H atoms are heated by thermal conduction and excited by collision. During Solar flares, $H\alpha$ is



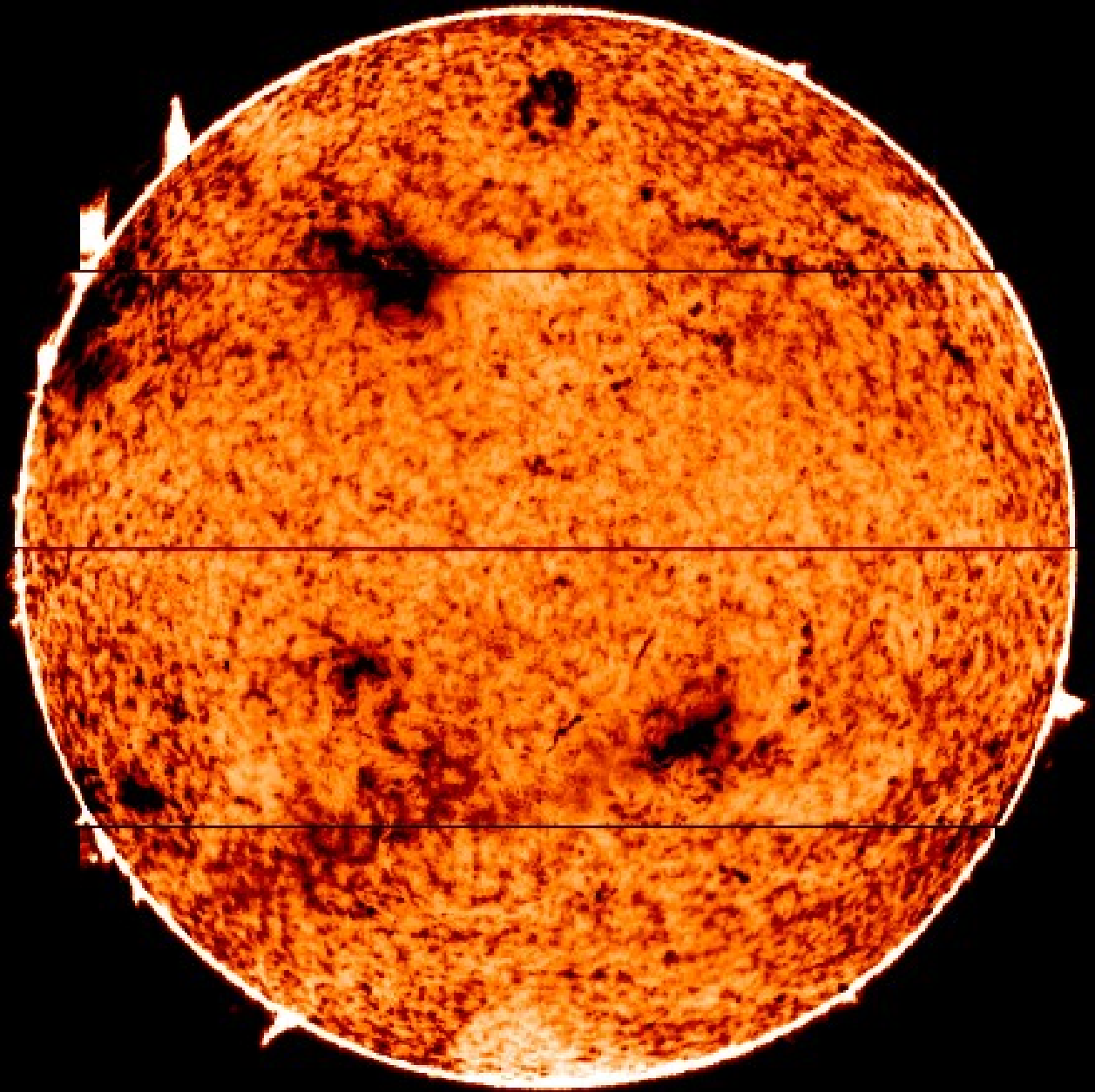
Sun,
KPNO, He I

He I 10830

□

spectroheli
ograms
from the
U.S.
National
Solar
Observator

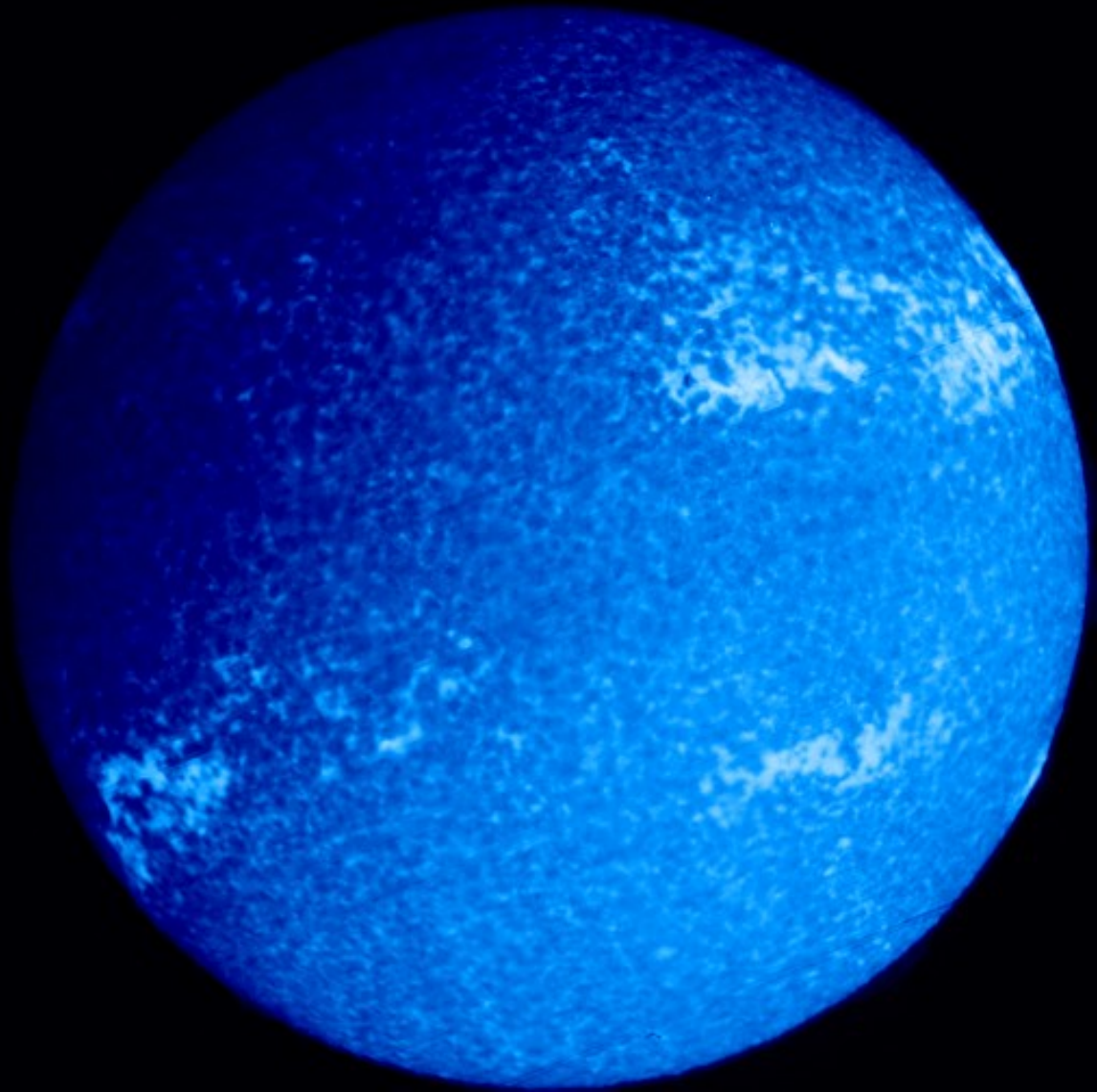
Early observations of
He I emission,
coupled with its high
ionization energy (~ 20
eV), revealed
temperatures at the
chromosphere and
corona much hotter
than at the
photosphere. The He
lines are much weaker
in coronal holes and
are enhanced in



Sun, USNSO

**Ca II K 8542 λ
spectro-
heliograms
from the
U.S. National
Solar Observ
atory at Sacr
amento Peak N
M (060199)**

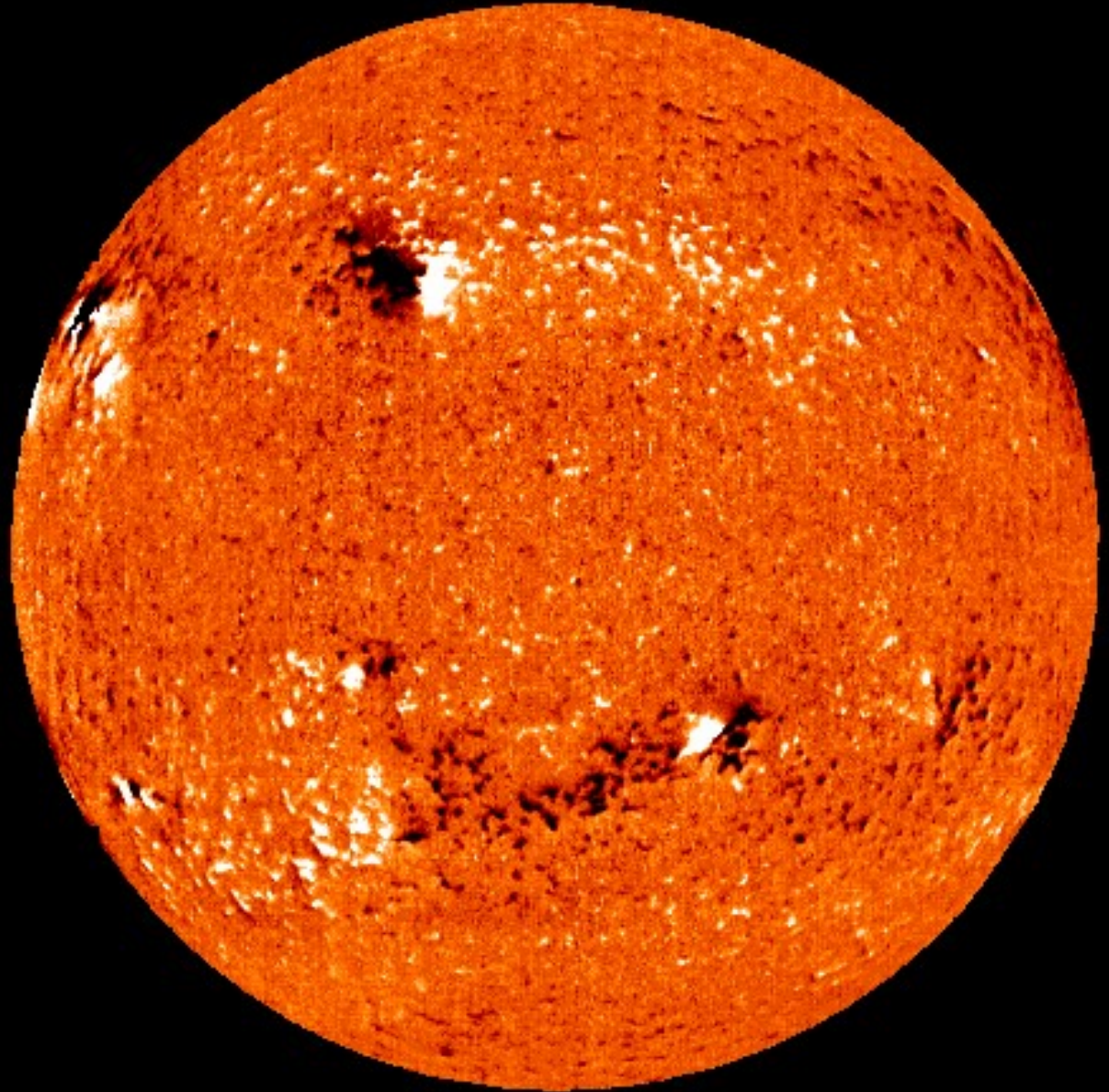
The Ca II
resonance spectral
line serves as a
diagnostic for
plasma properties,
activity levels and
magnetic influence
of the Solar
chromosphere. The
differential
emissivity provides a



Sun,
KPNO, Ca II

Ca II 8542 λ
magnetogram
s
from the
U.S. National
Solar Observ
atory
at Kitt
Peak, AZ
(070299)

Ca II
magnetograms
reveal clumps of
magnetic structure
that diagnose
convective motions
which transport
energy from the
Solar interior.



Sun, KPNO, magnetogram

**Photospheric
magnetograms
from the
U.S. National Sol
ar Observatory
at Kitt Peak AZ
(070299)**

Standard
photospheric
magnetograms at
6303 Å trace the
magnetic field
orientation at the
surface of the Sun.
Together with
observations of bright
points, plumes, and
active regions, one
obtains a picture of the
turbulent mhd activity
occurring at the Solar



Sun, MLSO, Coronameter

MLSO—MK3 Coronameter

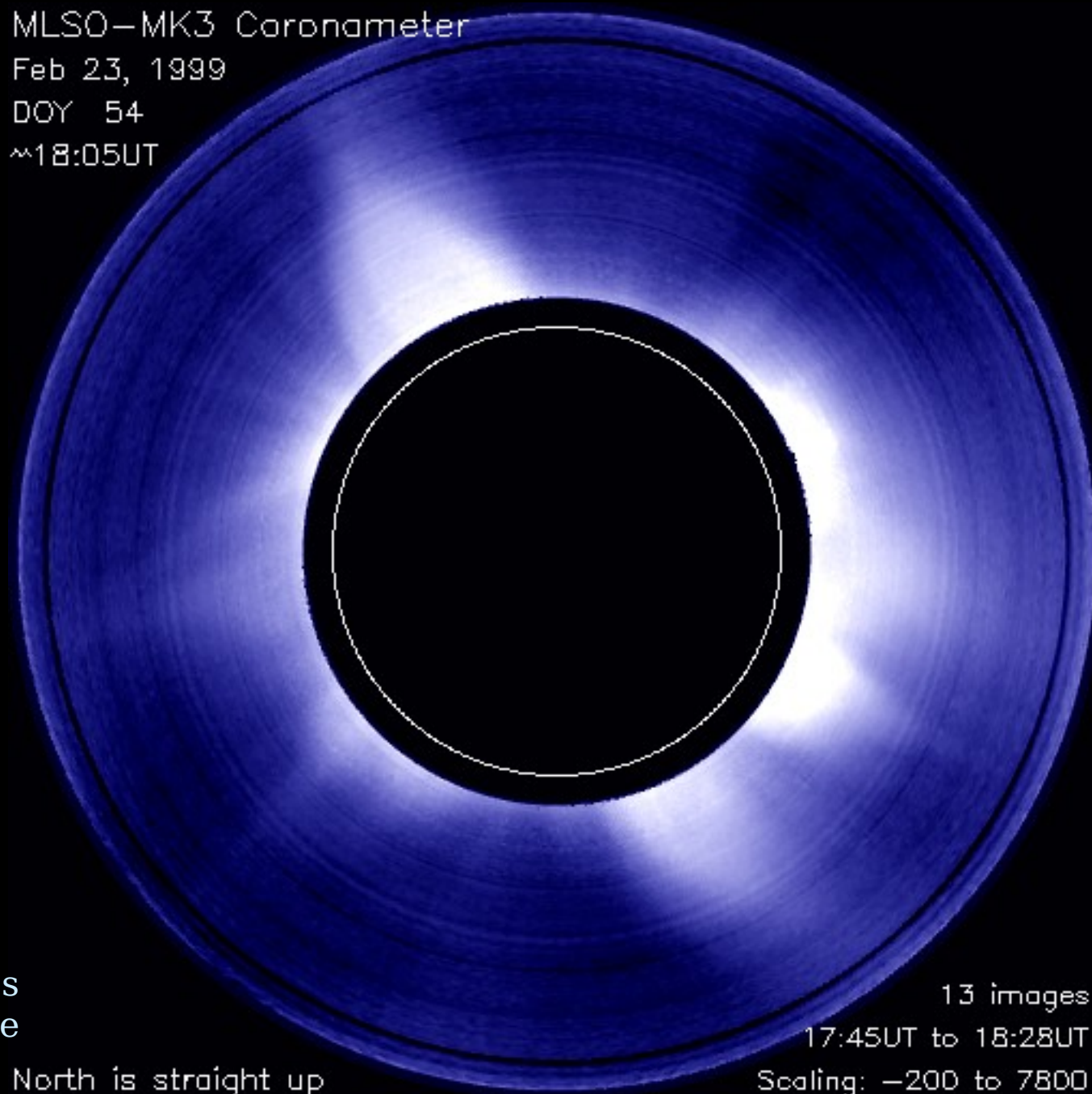
Feb 23, 1999

DOY 54

~18:05UT

**White-light
coronameter
images from
the
High Altitud
e Observator
y Mauna Loa
Solar Observ
atory
(022399)**

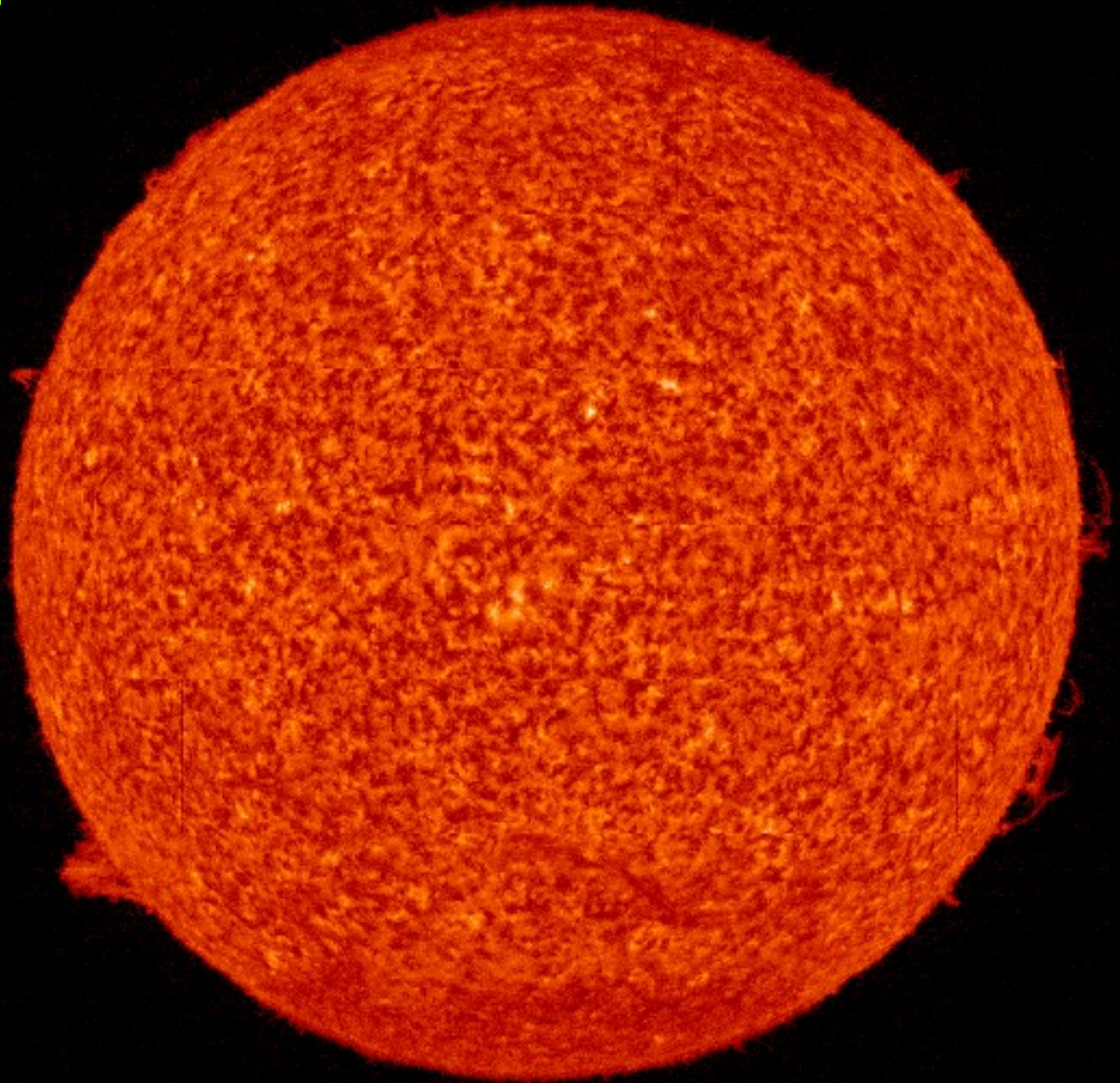
White light
(integrated Solar
emission between
4000 and 7000 Å)
coronameter images
reveal activity of the
corona



Sun,
LASCO SUMER,
He I

**He I 584.3 \AA
emission
line
observed
with
SUMER on
2-4 March
1996**

Sun observed in
He I, formed in the
upper **chromosphere** at
about 20,000 K. The
picture was put together
from eight horizontal
raster scans in alternating
directions, starting in the
solar NE. Each raster
scan includes 1600
exposures, lasting 7
seconds each. The picture
is shown in bins of 4x4



Sun,
SOHO EIT
, He II

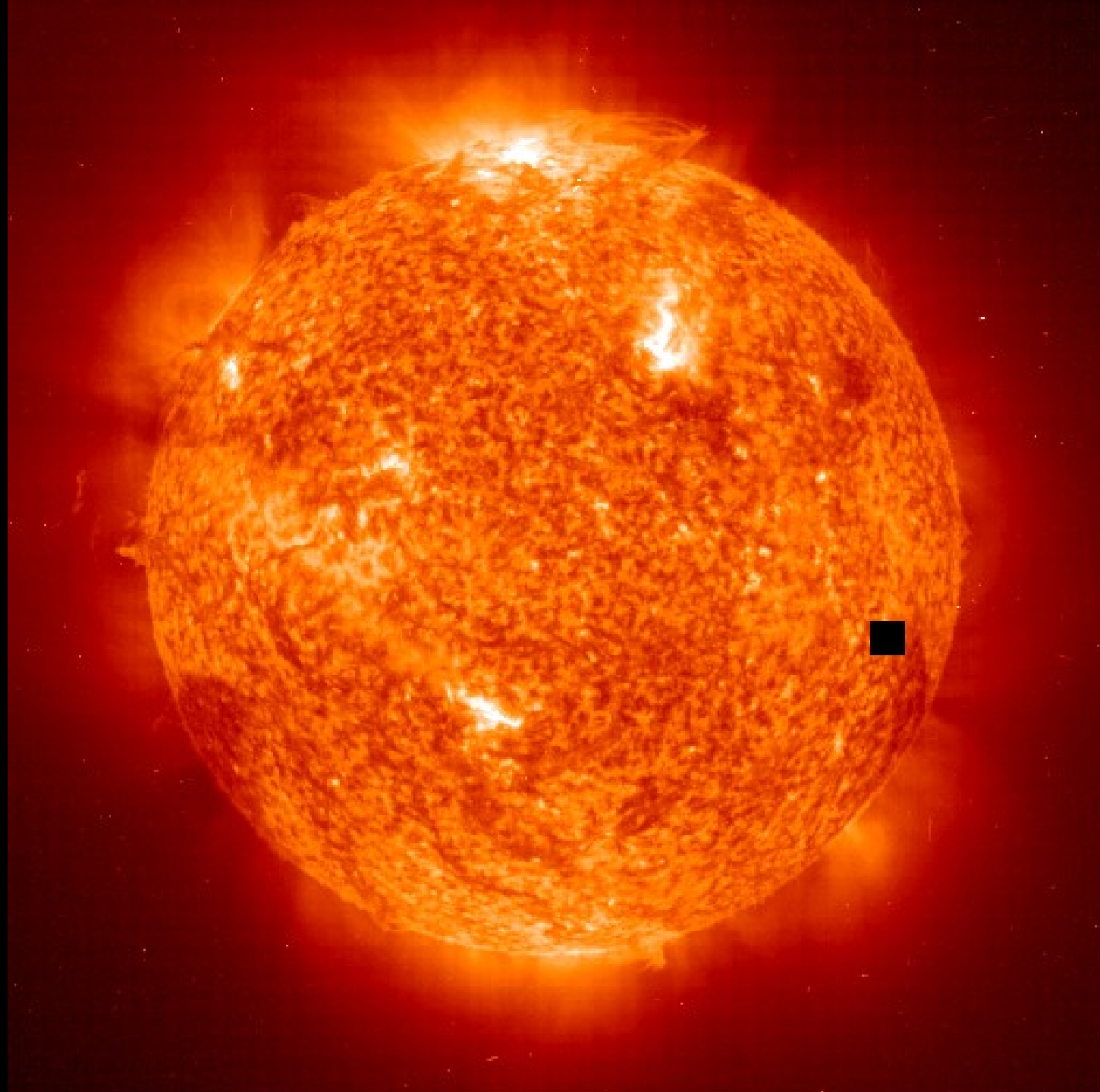
Full-field
HeII

304 Å

image

(070299)

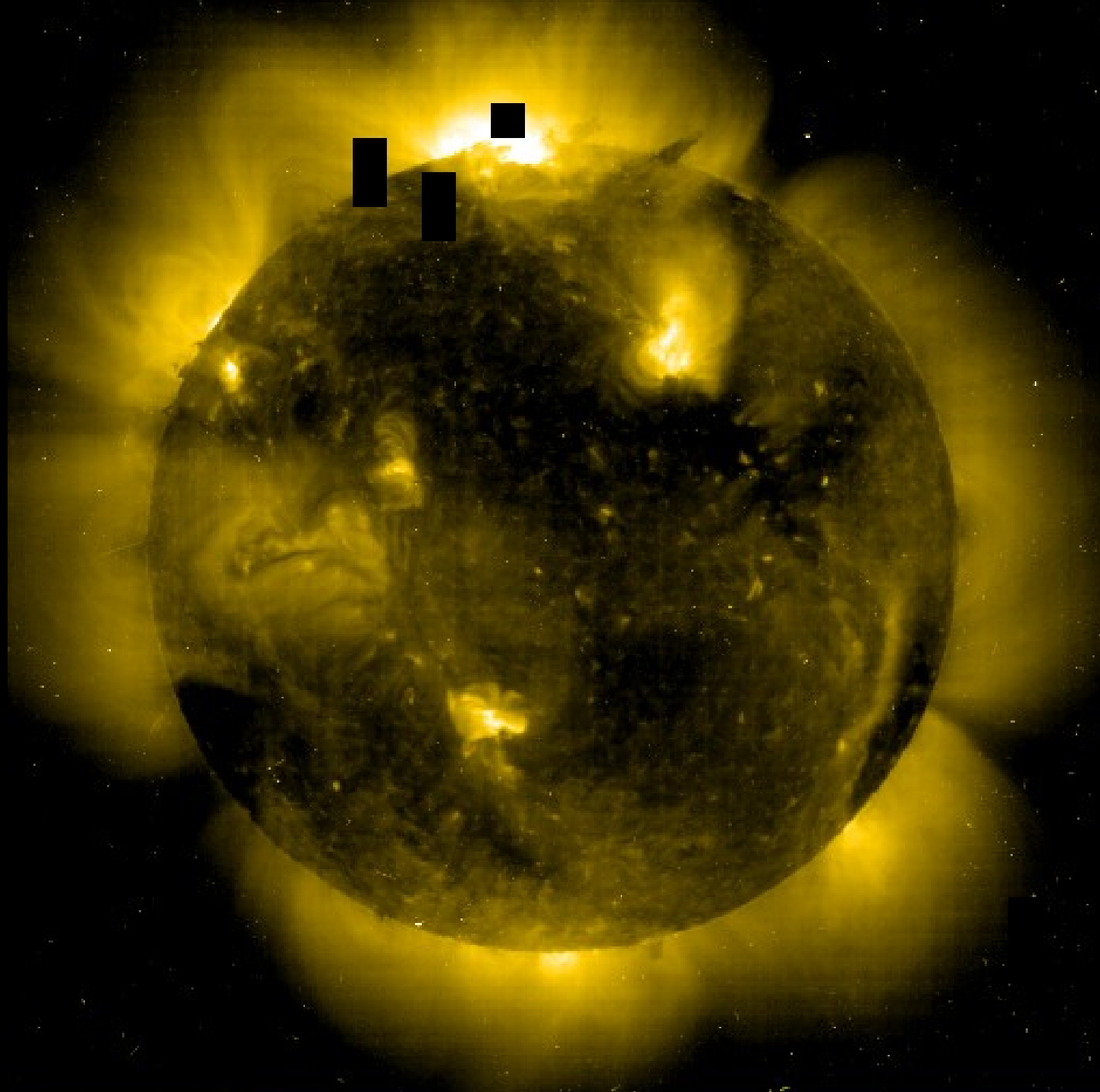
He II emission in the extreme UV is formed by excitation and ionization of He by energetic beamed electrons produced in the low chromosphere. The formation of electron beams may be due to magnetic reconnection in flare loops



Sun,
SOHO EIT ,
Fe XV

**Full-field
Fe XV
284 Å
image
(070299)**

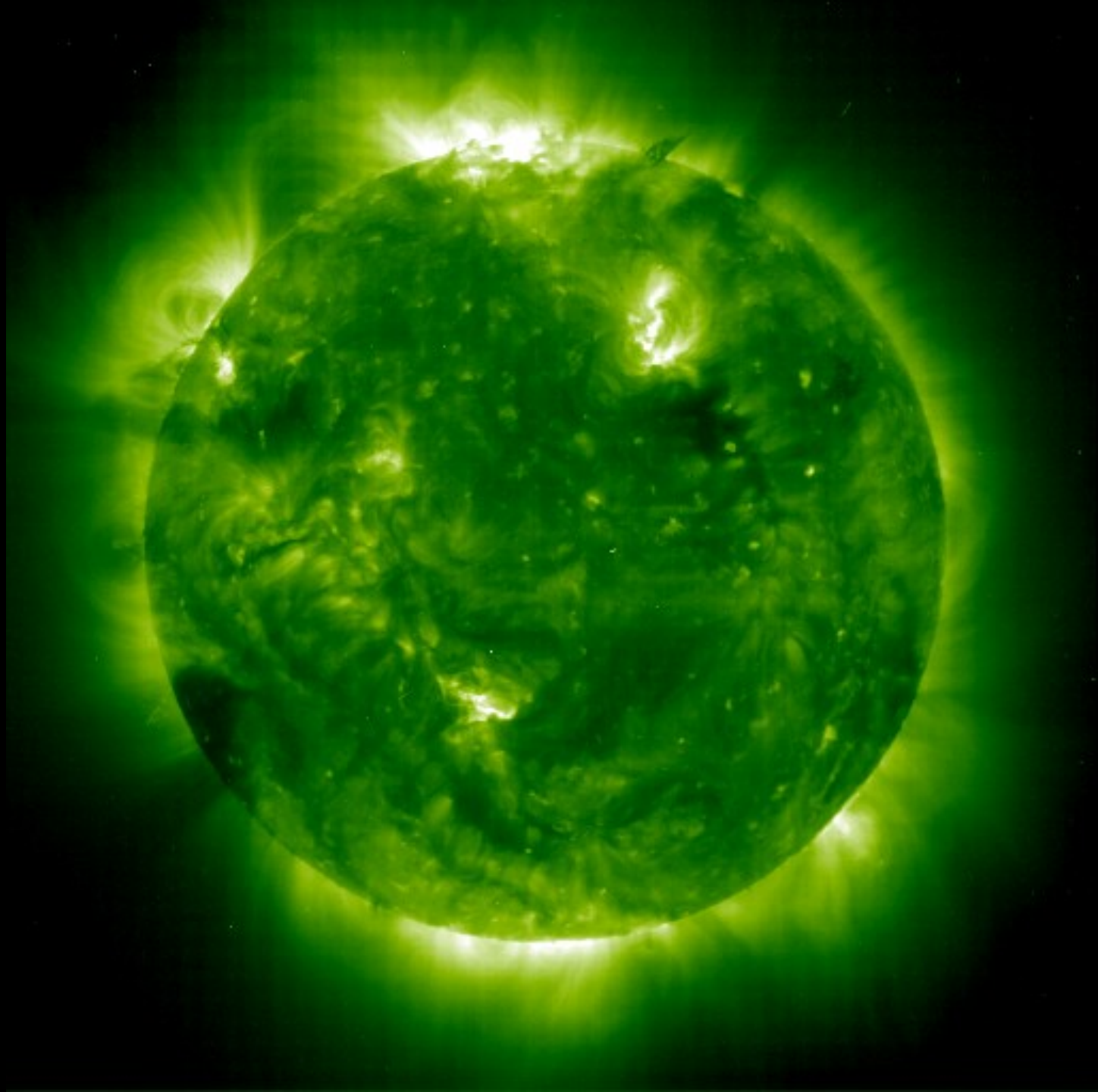
Fe XII-XVIII
Full- disk images
in FeXII 195 Å and
FeXV 284 Å allow
study of the
properties of the
quiet corona
outside and inside
coronal holes.



Sun,
Soho EIT
, Fe XII

**Full-field
Fe XII
195 Å
images
(070299)**

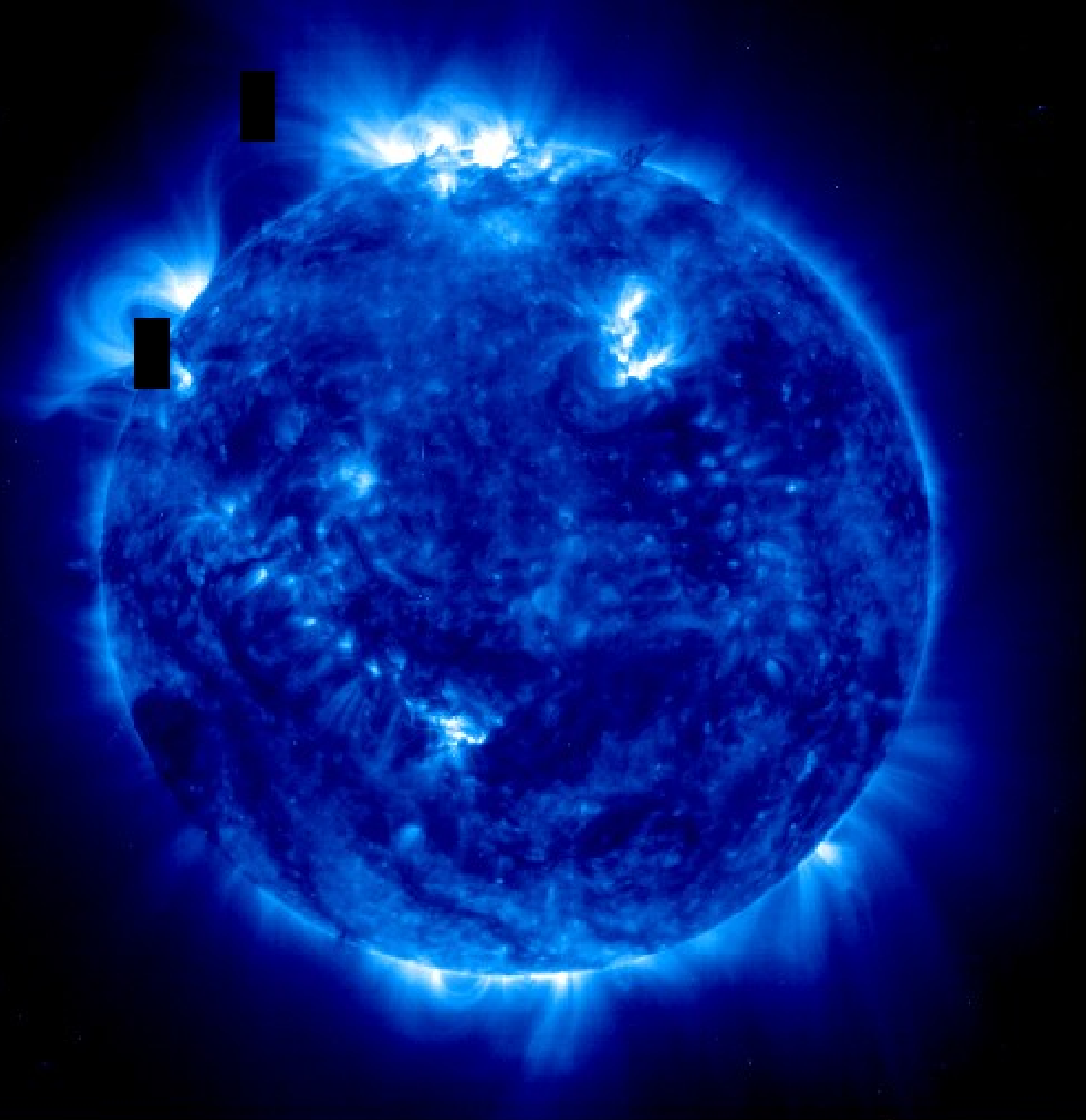
Fe XII-XVIII
emission is
formed in the low
corona (2×10^6 K)
of the Sun and is
due to
recombination of
electrons with
ionized Fe.



Sun,
SOHO EIT
, Fe IX

Full-field
Fe IX, X
171 Å
images
(070299)

Full Sun EUV
images in FeIX-X
171 Å show the
latitude-time
distribution of the
X-ray bright points
and their relation
to the structures
inside
coronal holes.



Sun, Yohkoh

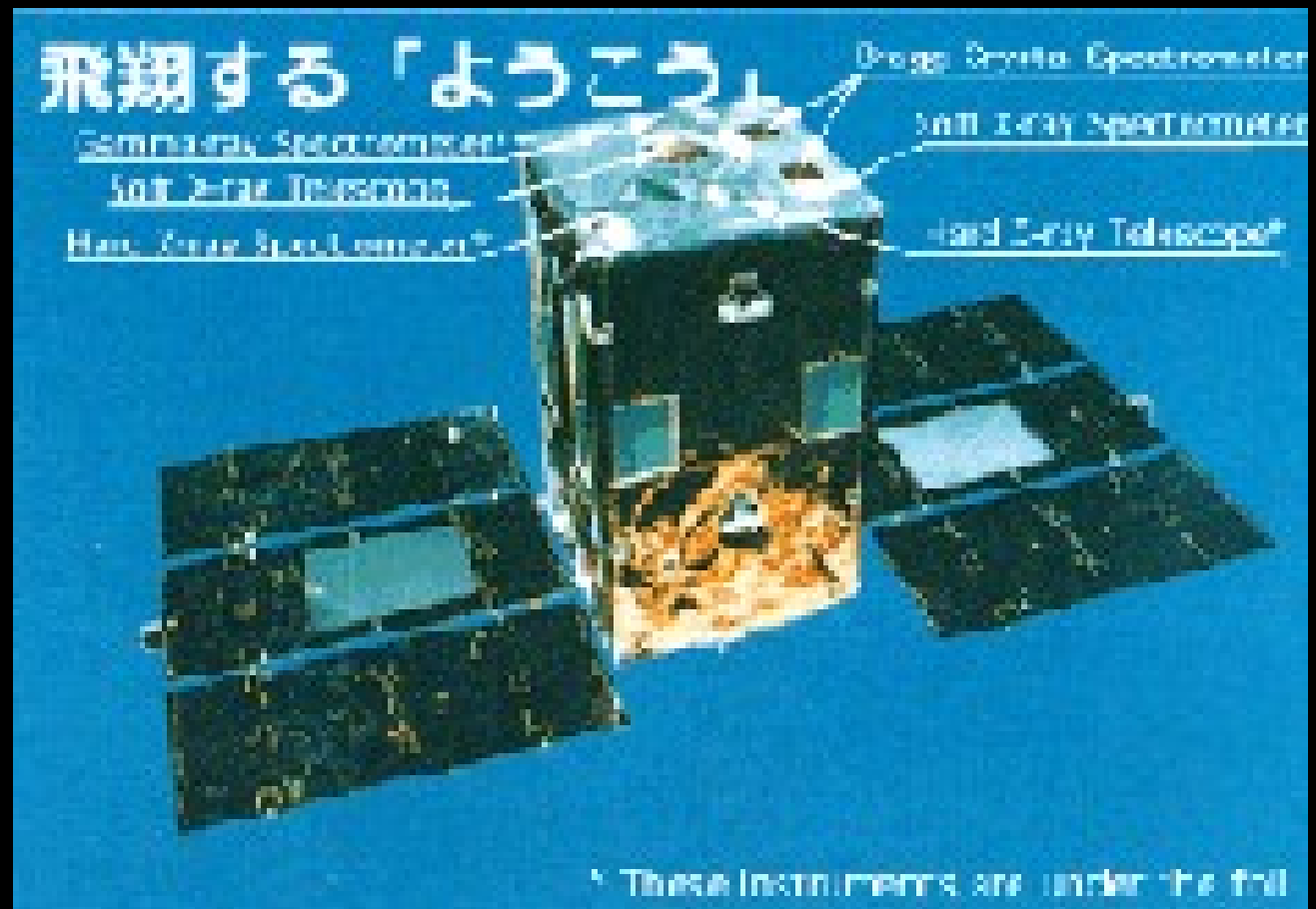
**Yohkoh
soft X-ray
telescope
(SXT) full-
field
images
from the
Hiraiso
Solar
Terrestrial**

**Research X-
ray
Center
(040299)**

rays come
primarily from
thermal and
nonthermal
continuum electron
bremsstrahlung and
X-ray lines due to
the excitation of
inner shells of ions



Yohkoh Satellite



Yohkoh ("Sunbeam" in Japanese) is a satellite dedicated to high-energy observations of the Sun, specifically of flares and other coronal disturbances. The *Yohkoh* mission was launched on August 30, 1991, from the Kagoshima Space Centre in southern Japan. The spacecraft carries a payload of four scientific instruments: the Soft X-ray Telescope (SXT), the Hard X-ray Telescope (HXT), the Bragg Crystal Spectrometer (BCS) and the Wide Band Spectrometer (WBS). The SXT (which is sensitive in the range 1-2 KeV) takes images in various wavebands (selected by filters) using a CCD - either the full CCD frame, or a selected part of the CCD frame is returned in telemetry - these are known as full frame, and partial frame images (FFI and PFI); the HXT (which is sensitive in the range 10-100 KeV) measures Fourier components in 4 channels through a set of 64 pairs of grids - the images are reconstructed on the ground; the BCS observes the line emissions of Fe XXVII, Fe XXVI, Fe XXV and Fe XXIV; the WBS observes the line emissions of Fe XXVII, Fe XXVI, Fe XXV and Fe XXIV.

SOHO Satellite

- The solar interior

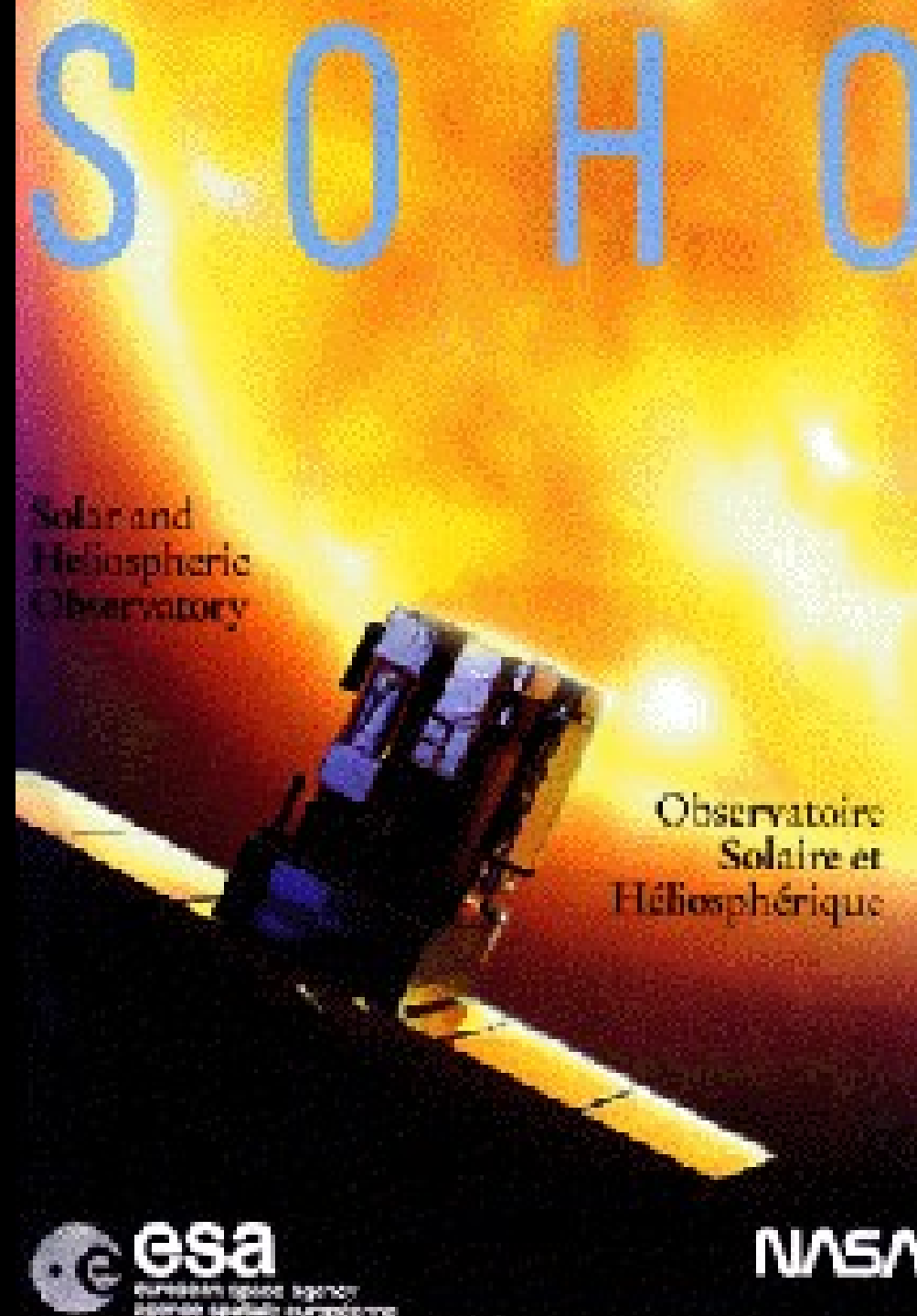
GOLF and **VIRGO** will perform long and uninterrupted series of oscillations measurements of the full solar disk, respectively in velocity and in the irradiance domain. In this way, information will be obtained about the solar nucleus. **SOI/MDI** will measure oscillations on the surface of the Sun with high angular resolution. This will permit to obtain precise information about the Sun's convection zone - the outer layer of the solar interior.

- The solar atmosphere

SUMER, CDS, EIT, UVCS, and LASCO constitute a combination of telescopes, spectrometers and coronagraphs that will observe the hot atmosphere of the Sun, the corona, extending far above the visible surface. **SUMER, CDS** and **EIT** will observe the inner corona. **UVCS** and **LASCO** will observe both inner and outer corona. They will obtain measurements of the temperature, density, composition and velocity in the corona, and will follow the evolution of the structures with high resolution.

- The solar wind

CELIAS, COSTEP and **ERNE** will analyze *in situ* the charge state and isotopic composition of ions in the solar wind, and the charge and isotopic composition of energetic particles



esa

European Space Agency
Agence spatiale européenne

NASA

National Solar Observatory Kitt Peak



The National Solar Observatory (NSO) is part of the National Optical Astronomy Observatories (NOAO) which was formed in 1984. NSO operates two major observatory sites. On **Sacramento Peak** in southern New Mexico (picture shown above left), major telescopes include the Vacuum Tower Telescope, the John W. Evans Solar Facility, and the Hilltop Dome. Sacramento Peak has been a center of solar research since 1950; the observatory is a cooperative undertaking of NSO and the Air Force Phillips Laboratory. On Kitt Peak, outside of Tucson, Arizona, NSO

Mauna Loa Solar Observatory

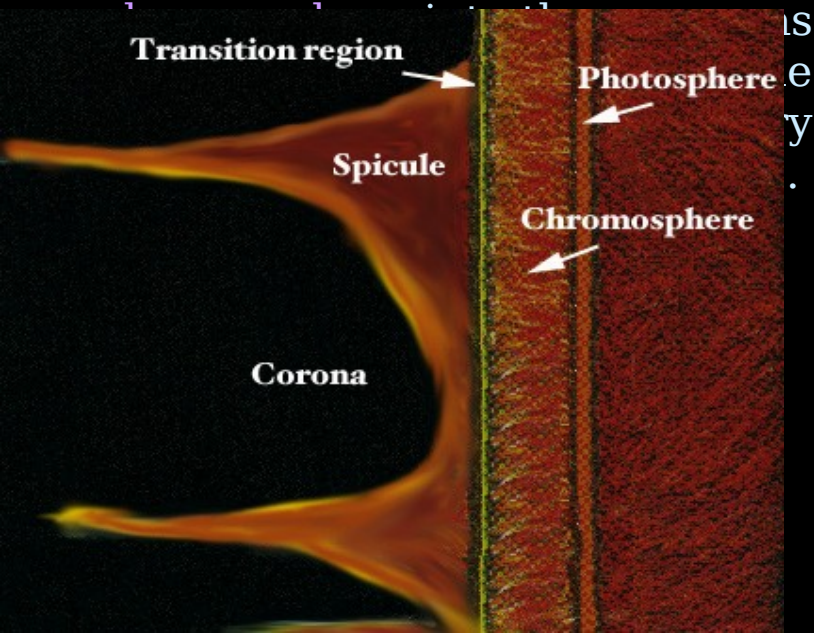


The Mauna Loa Solar Observatory (MLSO) operates daily, weather permitting. Data collected by instruments at the site are:

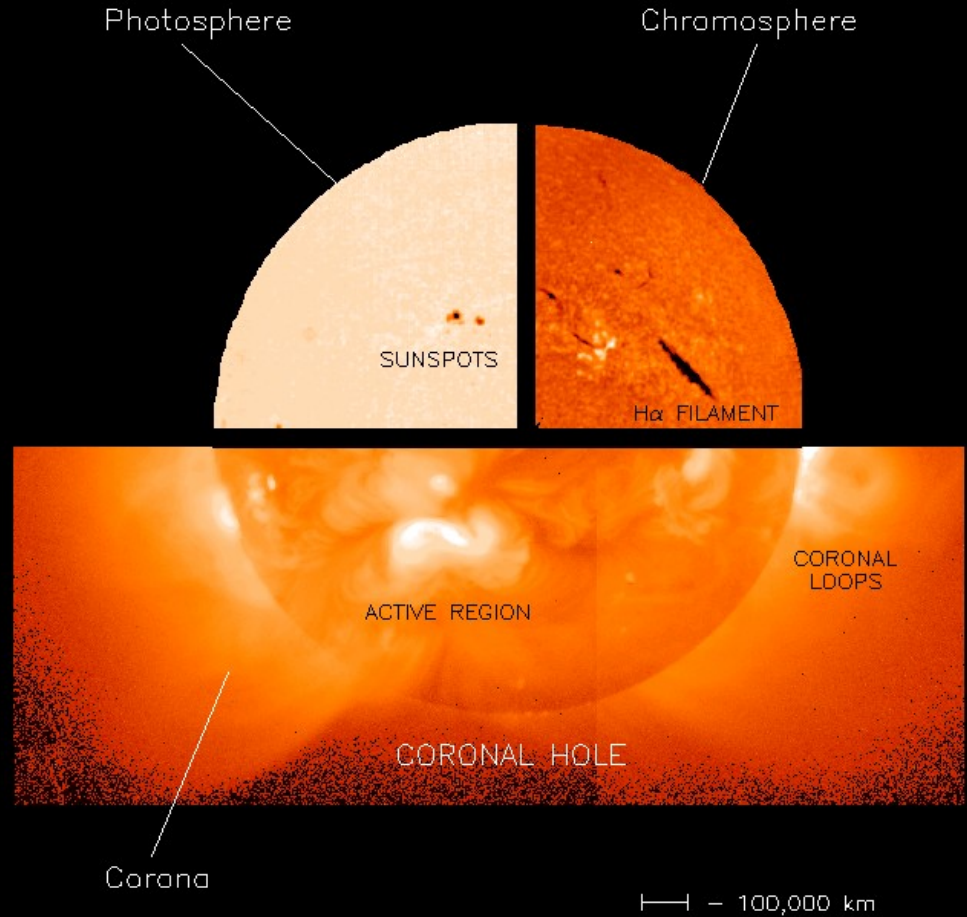
- **H α disk and limb** images, collected with the digital prominence monitor.
- **Coronal images in white light polarization brightness**, collected with the Mark 3 K-coronameter.
- **Solar oscillation data** collected with the Low Degree instrument.
- **Helium I** images, collected with the Chromospheric Helium I Imaging Photometer

Solar Atmospher

The **photosphere**, shown as an orange vertical line, is the region where sunspots are formed. The less dense and turbulent **chromosphere** is a rapidly-changing filamentary structure that is seen during eclipses as a bright red ring around the Sun. The intensely active transition region, illustrated by the vertical yellow line, was first observed in detail by Skylab in the late 1970s. Spicules extend the



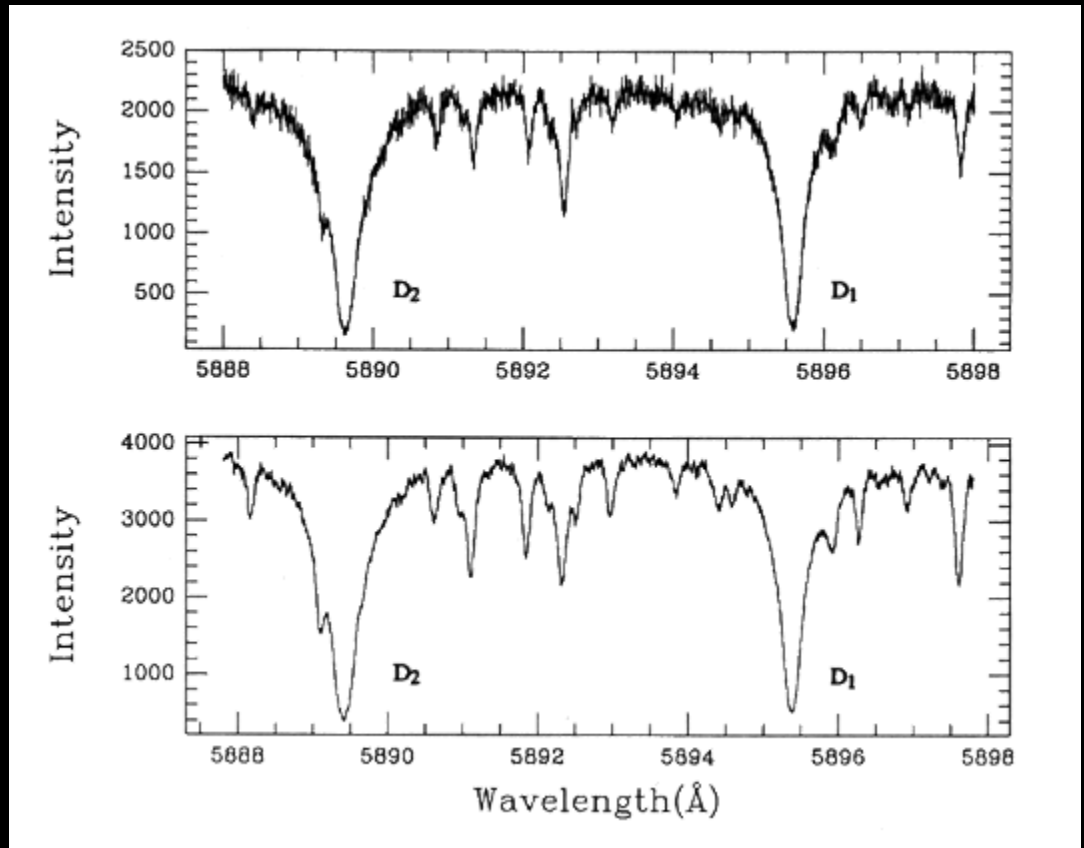
THE SOLAR ATMOSPHERE



Photosphere

Figure shows two scans of the solar spectrum in the region of the sodium Fraunhofer D lines at 5890 Å and 5896 Å.

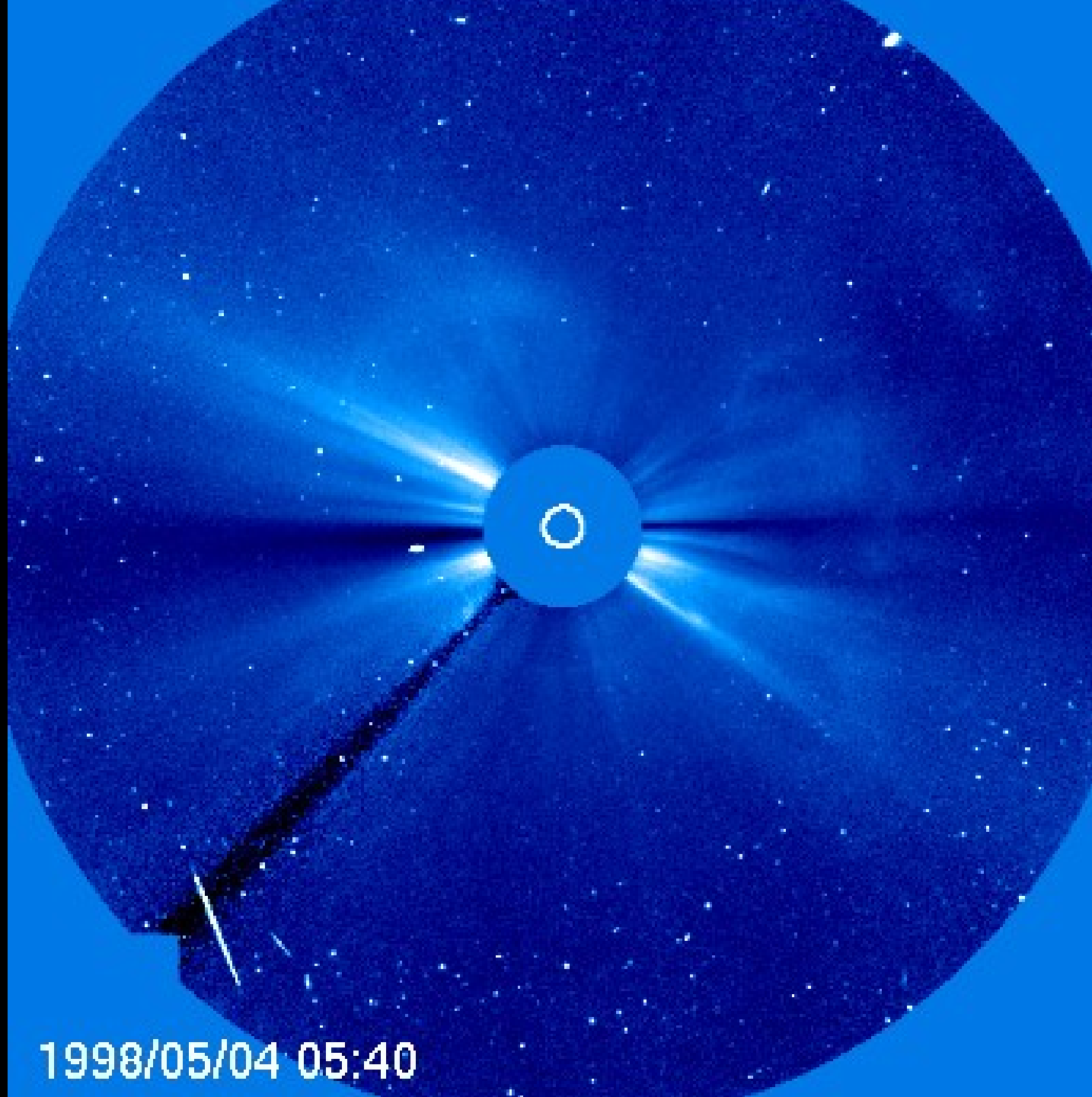
Several of the weaker features are due to water vapor in the earth's atmosphere, and show different strengths in these two scans because of the difference in



The Solar photosphere is the region that is optically thick to visual continuum light; thus it is the lowest portion of the Solar atmosphere that can be observed with optical telescopes. Solar spectra show continua and emission and absorption lines. In the visible region, however, the sun shows an absorption line spectrum superimposed on a quasi-blackbody continuum formed in the solar interior. The absorption lines are formed as the continuum radiation passes through the cooler outer layers of the sun and through the earth's atmosphere. Each line corresponds to one (or more, in the case of several close, blended features) absorption line. Physical

Corona

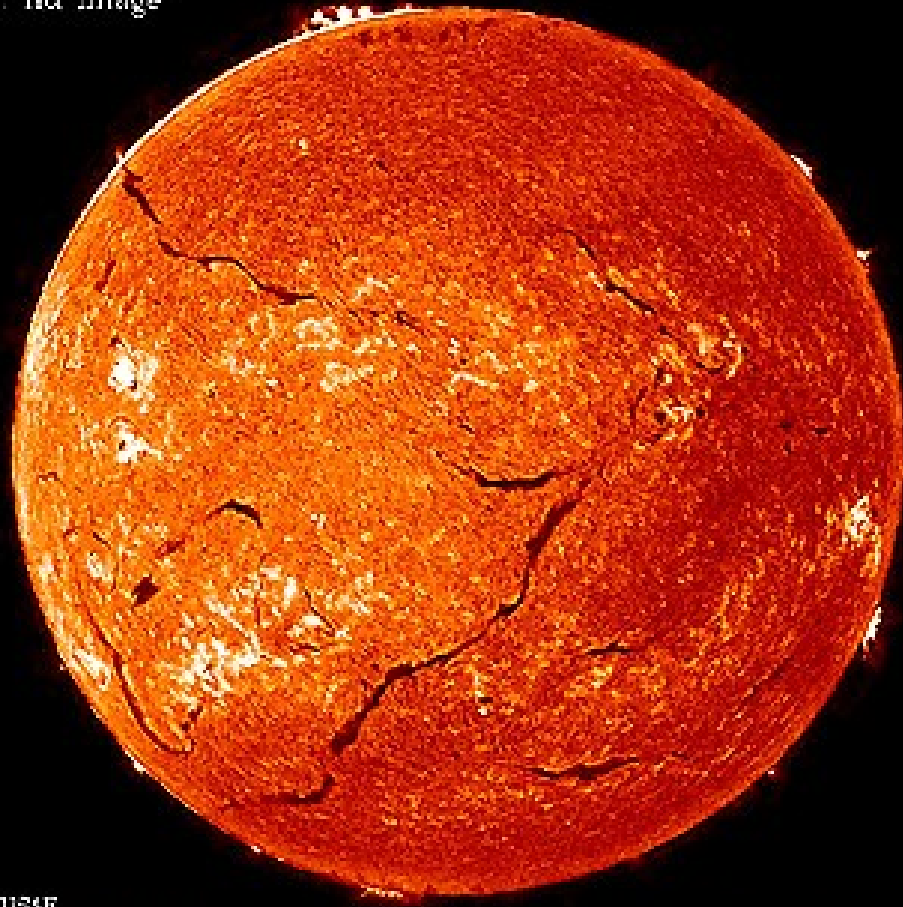
The Solar corona is the outermost layer of the solar atmosphere, characterized by low densities ($<10^9 \text{ cm}^{-3}$) and high temperatures ($>10^6 \text{ K}$) that extends to several solar radii. The shape of the corona is different at solar maximum and solar minimum. The heating of the corona has been a long-



1998/05/04 05:40

11 August 1980: H α image

Chromosphere

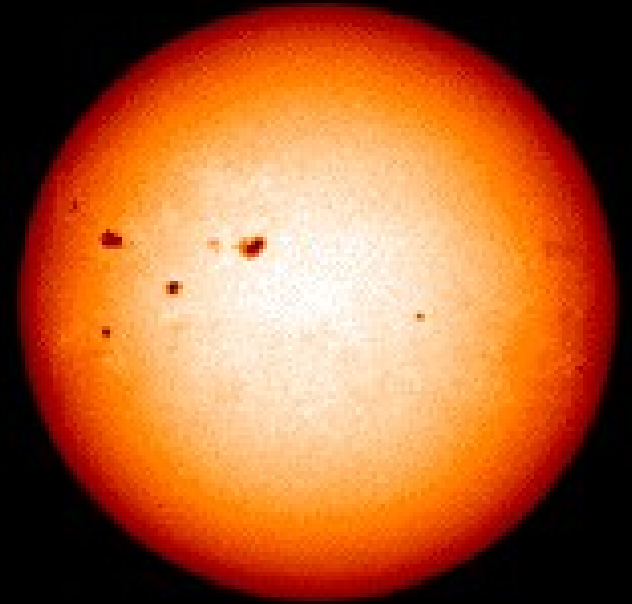
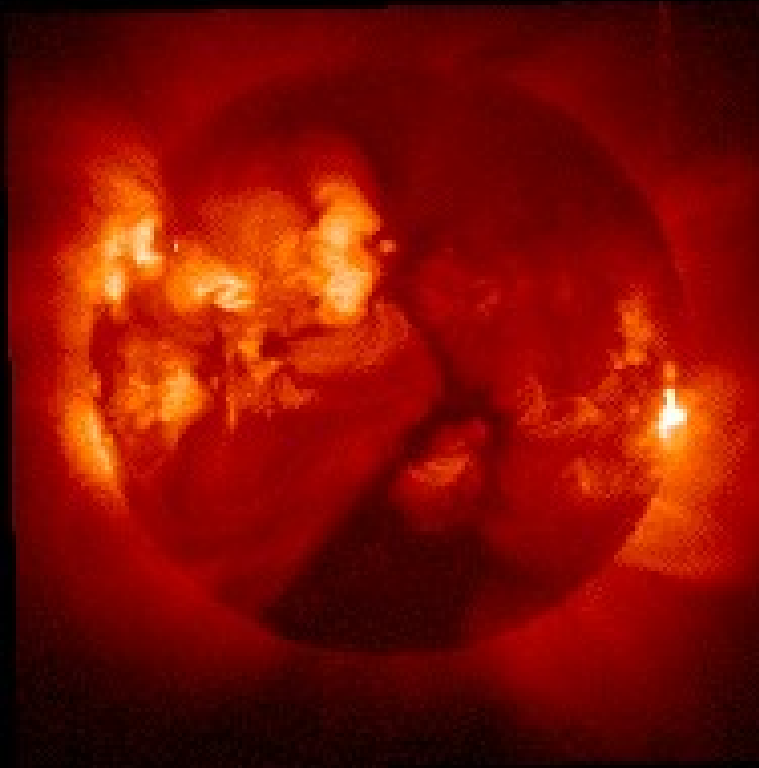


Source: NOAA/SEL/USAF

H10 A-005

The Solar chromosphere is the ~2000 km thick layer of the **solar atmosphere** above the (temperature-minimum) transition region and below the **corona**. Being transparent in the continuum, it is seen during eclipses as a bright red ring around the Sun. Energy is transported by radiative diffusion through the chromosphere, which reveals itself most strongly in the light of H α and CaII K. Views of the chromosphere show convective cell patterns similar to those in the photosphere, but much

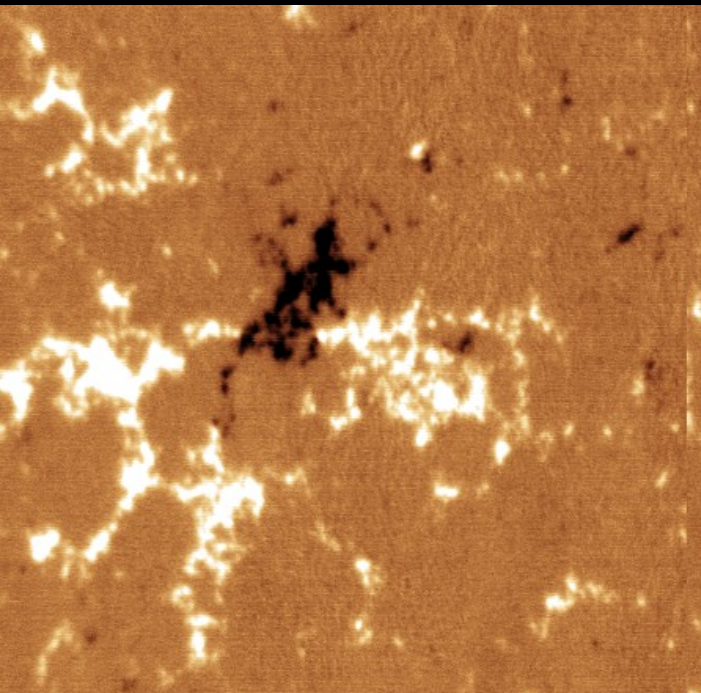
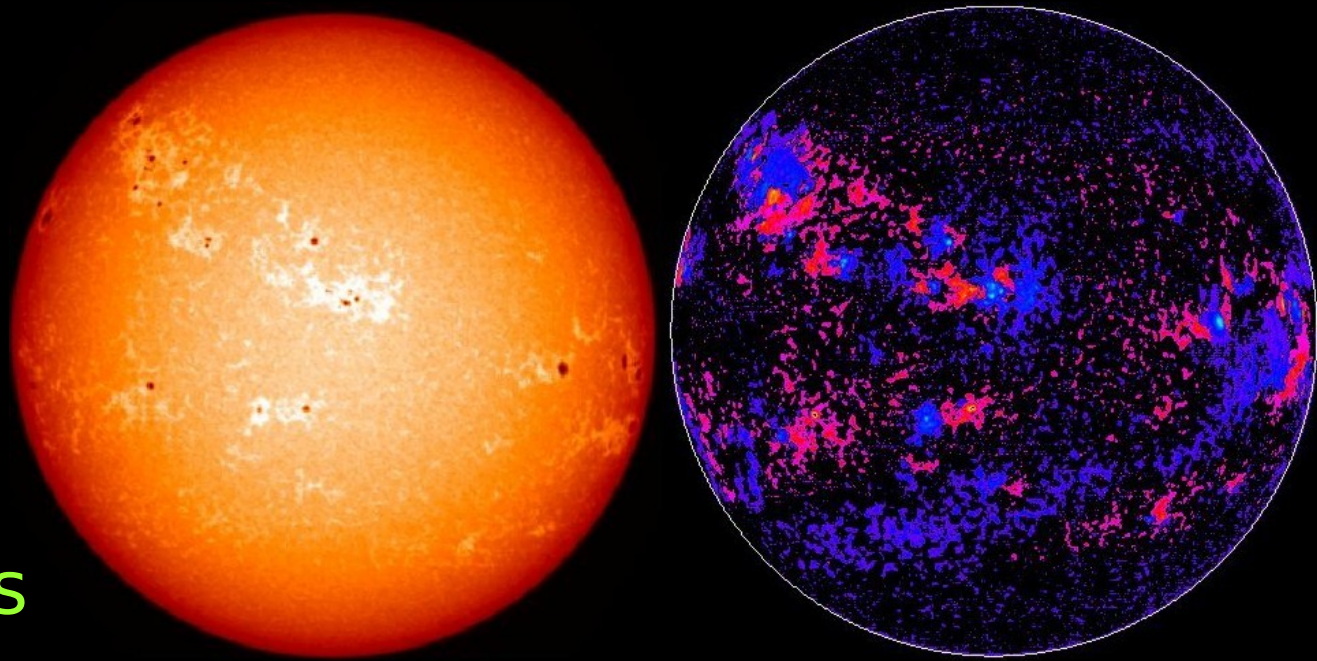
Coronal Holes and Active Regions



This image at left from [Yohkoh](#) shows the Solar [corona](#). The bright features represents magnetically-trapped plasma. In contrast, the dark regions, known as **coronal holes**, are where the Sun's magnetic field extends out into space, allowing the hot gas to escape. These regions contain material which is cooler than the surrounding $\sim 10^6$ K plasma seen in soft X-rays, and often appear near the Sun's poles as seen above.

Active regions are formed when magnetic field lines of the Sun emerge from the [photosphere](#) and open into the [corona](#). Hot gas is visible near the magnetic field, making bright loops. Active regions may last for

Solar Magnetograms



Magnetograms are maps of the line-of-sight component of magnetic flux at the photosphere, the sun's visible surface. The fields are measured by detecting the Zeeman shift between right-hand and left-hand circularly polarized light in a suitable magnetically sensitive absorption line. Only the line-of-sight component can be measured this way. Upper left: 10 Å Ca K line; upper right is corresponding magnetogram. Light and dark areas in image at left show where the field is large and directed out of and into the Sun, respectively.